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THE FELDSTEIN-HORIOKA PARADOX
A SELECTIVE SURVEY OF THE LITERATURE

by

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June 1996

Abstract

The paper provides a selective survey of the literature on the Feldstein-Horioka paradox. The observed high correlation between national savings and domestic investment emerges as a robust empirical regularity. If this regularity is to be attributed to low capital mobility (due to government interventions or market imperfections) or other factors (such as immobility of goods, shocks or intertemporal budget constraints) cannot be resolved. The empirical evidence on the relative importance of the possible factors is too sketchy. Excluding government interventions, the possible impact of market imperfections in causing saving-investment corrrelations has hardly been investigated so far.

JEL Classification: E44, F21, F32

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I. Motivation

For economists, assessing the degree of international capital mobility is of decisive importance. Its knowledge is a prerequisite for appraising the efficiency of the worldwide allocation of capital (Lucas, 1990). For if capital cannot or does not flow freely, obviously it will not be invested where its productivity is highest. And the degree of capital mobility is crucial for the evaluation of macroeconomic policy measures. For example, a government intending to levy a tax on capital will face considerable difficulties in enforcing it if the tax can easily be evaded by transferring the capital abroad. A government accruing high public deficits will provoke a crowding out of private investment more easily if it can only draw on national resources because capital is immobile entailing that foreign capital is not readily available.

Proportional to the importance is the attention capital mobility receives in the academic circles and the political field, even more so since there is substantial disagreement on its appropriate assessment and therefore on its degree. To a great extent the dissention was spurred by a seminal paper of Feldstein and Horioka (FH) (1980) in which they found capital to be almost immobile. Their findings boldly rejected the conventional conviction of that time. It was widely believed that the degree of capital mobility was high for it was observed that the amount of capital traded daily on the international bond or foreign exchange

markets was tremendous (and therefore capital markets were supposed to be highly integrated). This contradiction, i.e. apparently low capital mobility despite supposedly highly integrated capital markets, became known as the *Feldstein-Horioka paradox*. Not surprisingly, it spurred a variety of further investigations into the matter.

The objective of this paper is to provide a survey on this highly controversial approach of assessing capital mobility in order to gain a comprehensive, up-to-date impression of the state of discussion. The paper starts with some reflections on the nature of capital mobility (chapter 2). Then I will turn to discussing the FH theorem and present the original results they obtained. The efforts undertaken in order to reject the original results and some benchmark tests for evaluating them are attached (chapter 3). In chapter 4, the main attempts to resolve the paradox are described. They are subdivided into those that assume capital mobility to be perfect and those that doubt it. In the final chapter, the evidence and its possible explanations are summed up and the explanations are discussed with regard to their compatibility with each other as well as the empirical evidence, their explanatory power and the remaining shortcomings.

II. Grasping Capital Mobility

Since Feldstein and Horioka are concerned with measuring the degree of capital mobility, it will be helpful to start with some reflections on three questions: a) What is capital?, b) When is capital regarded as mobile?, c) What forms of capital movements exist?

The term „capital" applies strictly speaking only to physical capital. It can be formed by either investing physical or financial goods. Frequently the financial goods are also referred to as financial capital (as will also be done in this paper) which can further be subdivided according to

- its maturity: The maturity can theoretically differ between a couple of hours or infinity.
- its degree of heterogeneity: Short-term liquid assets in the same currency are regarded as almost homogenous, whereas long-term bonds denominated in different currencies and issued by different companies might display a high degree of heterogeneity. The higher is the degree of homogeneity, the higher the degree of substitutability will be.

As to the second question, there is no widely accepted definition of the term „capital mobility". Rather, opinions differ substantially on what is considered to be (almost) perfect capital mobility. A very lenient way to define it is speaking of

capital mobility if the residents of one country are free to trade assets with residents of another country (Montiel, 1993). The most demanding definition assumes capital mobility to be perfect only if all assets are perfect substitutes of each other (Frankel, 1986). Generally it is not possible to provide one single definition of capital mobility since the definitions in the presented literature vary considerably.

The third question is asked because capital being mobile is equivalent to potential capital movements being unhindered. By looking at the different forms of capital movements, one gains insights into different forms of capital mobility. It is convenient to start with the definition of international capital movements as suggested by Rose (1989): An international capital movement is a transaction changing the amount or the composition of the assets or the liabilities held in or owed to the rest of the world. Different forms of capital movements can be distinguished by answering three questions:[1] a) Does a transaction involve physical *and* financial or *only* financial capital? b) Does the capital cross a border? and c) Does the ownership (or the debtorship respectively) of the capital change across national boundaries?

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[1] The following scheme is based on an idea put forward by Sinn (1992).

Table A: ***Categories of Movements Involving Physical And Financial Capital***

	Does physical *and* financial capital cross a border?		
		Yes	**No**
Does a change in ownership across national boundaries occur?	**Yes**	– International trade in capital goods I.	– International trade in equities (direct investment) II.
	No	– International movements of capital goods (direct investment) III.	– Domestic transactions IV.

Table B: ***Categories of Movements Involving Only Financial Capital***

	Does *only* financial capital cross a border?		
		Yes	**No**
Does a change in the debtorship across national boundaries occur?	**Yes**	– International bond trade – To make an international deposit V.	– National bond trade – To make a national deposit VI.
	No	– To make a deposit at an international branch of national debtor VII.	– To make a national deposit VIII.

Table A shows that four forms of capital transfers can be distinguished when physical *and* financial capital are involved in a transaction. The first form of

transactions including capital goods is obviously their trade, a change in the ownership as well as in the location of the capital good occurs (cell I.). Secondly, physical capital is involved if international movements of capital goods take place, but the owner does not change (cell II.). This is one form of direct investment. As a third possibility, the location of the capital good is unchanged, but its owner changes (cell III.). That is another form of direct investment namely when equity capital is bought. The fourth form to be distinguished are domestic transactions where neither the location nor the owner of the physical capital change (cell IV.).

Table B shows the different forms of financial transfers. If the financial capital crosses a border and if a change of the debtor occurs, one can speak of international bond trade or international deposits are made (cell V.). This will be the case if a resident of country A acquires bonds of country B and also has to acquire currency of country B in order to pay for it. If no financial capital crosses the border, but a change in the debtor occurs, this will be part of the domestic bond trade or a national deposit is made (cell VI.). Here for example, the a resident of country A buys a bond issued in country B, but already owns currency of country B. As a third possibility, the financial capital crosses a border but no change in the debtor occurs (cell VII.). In this case a deposit is made in an

international branch of a national investor. The fourth possibility again are purely domestic transactions (either trade or deposits) (cell VIII.).

It becomes obvious that capital mobility as such has to be considered as a generic term comprising the specific ease with which the different forms of capital transfers occur. Perfect international capital mobility (in the sense of Frankel) will only exist if one of the two following conditions hold:

- Either all capital movements of each category can occur completely unhindered or
- the different categories of capital movements are perfect substitutes of each other, so that restrictions in one category of capital movements are made up for by other categories of capital movement (e.g. if physical capital is not perfectly mobile, the international capital mobility as a whole will not be affected if equities are perfectly mobile and perfect substitutes of physical capital)

If the second condition does not hold, i.e. if the different categories of capital movements are not perfect substitutes of each other, any deviation from perfect international capital mobility as a whole can be caused by imperfections in any category of capital movements (e.g. the international trade in physical goods or the international trade in bonds can be hindered).

III. A Paradox Arises

III.1. The Approach of Feldstein and Horioka

In this chapter I will first present the approach of FH as such before examining which notion of international capital mobility has to be applied when working with the FH approach. Then the obtained results will be presented.

The Feldstein-Horioka approach: intuition, implication and estimation

FH's intuition in assessing the degree of international capital mobility is straightforward. They argued:

> „With perfect capital mobility, an increase in the saving rate in country i would cause an increase in investment in all countries; the distribution of the incremental capital among countries would vary positively with each country's initial capital stock and inversely with the elasticity of the country's marginal product of capital schedule"*(1980, p.318)*

Accordingly, there should be no systematic correlation between a country's saving rates and its investment rates. Frankel (1986) pointed out that three conditions are necessary if this hypothesis is to hold

- Investment has to depend only on the national rate of return,
- The domestic real rate of return equals the world real rate of return,

- The world rate of return is exogenous, i.e. it cannot be influenced by the specific country.

To test the hypothesis of no correlation between the savings and the investment ratios, FH determined the coefficient of

(II.1) $$\left(\frac{I}{Y}\right)_i = \alpha + \beta \left(\frac{S}{Y}\right)_i + \mu_i$$ μ: random variable

using ordinary least square (OLS) estimation where $\left(\frac{I}{Y}\right)_i$ is the ratio of gross domestic investment to gross domestic product and $\left(\frac{S}{Y}\right)_i$ is the corresponding ratio of gross domestic saving to gross domestic product in country i. Under perfect capital mobility, the correlation coefficient β should only depend on the country size. A very small country should show a very low correlation between its saving rates and its investment rates. For a larger country, the correlation coefficient should increase relative to the country's share of total world capital.[2]

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[2] In 1980 the correlation coefficent should have been, on average, lower than 0.10, if the investment ought to be regarded as uncorrelated with savings since none of the countries had a share of world capital markets exceeding 10 percent.

The notion of international capital mobility implied by FH

Before presenting the results of the estimation, I will turn to the question what has to be considered *international capital mobility* in the notion of FH. Savings and investment will only be uncorrelated if savings at home can be turned unhindered into investment either at home or abroad and that savings abroad can be converted unhindered into investment either abroad or at home. Ways of converting savings into investment can be gathered from table C.

Table C: ***The Different Ways of Converting Savings Into Investment***

	Are savings converted into physical investment?		
		Yes	**No**
Are the savings converted into investment abroad?	**Yes**	– Foreign direct investment is carried out (maybe requiring acquisition of capital goods from abroad) I., II., III.	– International bonds are acquired or international deposits are made V., VII.
	No	– National direct investment is carried out (maybe requiring the acquisition of capital goods from abroad) I., V.	– National bonds are acquired or national deposits are made VIII., VI.

So the conversion of savings into investment can comprise all categories of capital movements (Latin numbers referring to tables A and B). Accordingly, the FH notion of capital mobility comprises all kinds of capital movements.

Therefore, it is important to note that the FH approach *simultaneously measures the international mobility of physical and financial capital.* Thus, when interpreting the results it will be misleading to restrict the focus to financial capital mobility only, as is widely done in the literature. It will also be misleading to interpret the savings-investment correlation as an exclusive measure of the degree of physical capital mobility which has also been done.

The results obtained by FH

Since their findings were the starting point of an intensive debate on the degree of international capital mobility, they will be presented in a little more detail. The study covered the time period from 1960 to 1974 for which consistent data were available including 16 OECD countries.[3]. A cross-section approach (with pooled annual data) was chosen because it was suspected that a time series analysis might bias the correlation coefficient upwards due to a business-cycle induced parallel movement of savings and investment rates.

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[3] The components are derived as follows: GDP data and data on investment can be gathered directly from the NIA. Savings are computed by subtracting consumption fromavailable income. So instead of talking about domestic savings as FH did, one should really talk about national savings instead. It ought to be kept in mind, though, that the figureare not quite identical with real savings. For one thing, they contain the retained earnings that accrued to foreigners and should therefore be subtracted. Furthermore, retained earnings accruing on foreign assets to residents are omitted. Gross figures rather than net figures were used because of the incomparability of depreciation methods, also net figures did not alter the results substantially.

For the complete 15-year-period the estimated value of β was not significantly different from one, but significantly different from zero. The same held true for each of the five sub-periods 1960-1964, 1965-1969 and 1970-1974.

In order to silence anticipated criticism, they did some further tests to provide evidence on the robustness of these startling results. First, they corrected for the possible influence of the country-size. The reason for doing so is that larger countries are likely to be more self-contained than smaller ones (Harberger 1980). Whether Harberger's argument is conclusive, was checked by adding a variable of the intensity of the international trade to the regression, since smaller countries were expected to engage more intensively in international trade. So a regression of the form

$$\text{(II.2)} \qquad \left(\frac{I}{Y}\right)_i = \alpha + (\beta_0 + \beta_1 X_i)\left(\frac{S}{Y}\right)_i + \mu_i$$

was estimated where X_i measures the openness of the economy as the sum of exports and imports per dollar of GDP. Further they run the original estimation equation using the logarithm of GDP. The few largest observations should not dominate the outcome. Their results did not bear evidence of any influence of the country size on the correlation coefficient. Secondly, they also ran a two stage estimation to test for the possible endogeneity of savings since it is conceivable (in a short-term Keynesian framework) that a shock on investment might induce

changes in savings. On grounds of their findings this possibility could be dismissed.

To sum up, FH obtained savings and investment correlations which could be interpreted as evidence of capital being completely immobile internationally. Furthermore, they showed the results to be fairly robust neither finding an influence of the country size nor an indication of the endogeneity of savings.

III.2. Efforts to Reject the Original Results Fail

The results contradicted conventional wisdom which perceived capital to flow freely across national borders. Not surprisingly, they were intensively scrutinized.[4] The results were challenged on the grounds of econometric adequacy and by doubting the robustness of the findings. The econometric issues most extensively discussed were the adequacy of cross section versus time series analysis and if saving and the interest rate had to be treated as endogenous. Sample sensitivity was tested by altering the countries included (differing by

[4] See appendix 1 for a survey on studies published to the topic. I concentrate on studies adding new contributions to the issue.

number, their size, or geographical aspects) or the time period on which the regression was based.

Cross section vs. time series analysis

One of the most extensively discussed topics was whether cross section or time series analysis is more appropriate to produce reliable results. Among those who prefer cross section analysis, FH had claimed that it was better fitted to reflect reality because cyclical co-movements in savings and investment are likely to distort upwards a coefficient found in a time series analysis. An exogenous shock affecting both savings and investment might generate similar results. Those who are in favor of time series analysis claim that capital flows in reverse directions are ignored by a cross section analysis. Sooner or later current account deficits and surpluses have to cancel out, thus cross section approach analysis will produce artificially high correlation coefficients. In theory, both effects might be observed, so the matter had to be settled empirically. Obstfeld (1986) and Sinn (1992), among others,[5] estimated time series regressions and found the correlation coefficient to be generally lower than in cross section analysis. That might indicate that the cross section analysis generates the more serious bias. Nevertheless, even in time series analysis, the hypothesis of perfect capital

[5] For example, Frankel (1986), Penati and Dooley (1984).

mobility had to be rejected. It was significantly different from zero and from one. So the approach of a time series analysis was able provide evidence of capital mobility being higher than shown by FH, but still substantially lower than was widely believed.

Possible endogeneity of savings

If the right hand side variables are correlated with the disturbance term or are endogenous, OLS leads to biased and inconsistent estimations of the regression coefficient. Although FH had rejected the estimated β to be biased by the possible endogeneity of savings (possibly induced by shocks on demand), the issue was further scrutinized by Montiel (1994), this time by introducing instrumental variables. Searching for a variable closely correlated with savings, but presumably uncorrelated with investment, he chose government consumption and (one minus) the population dependency ratio. Recurring to these proxies left the results basically unchanged. The correlation coefficient remained significantly different from zero. According to his findings, it seemed justified to interpret the endogeneity of savings as a negligible problem.

Possible endogeneity of the world interest rate

The saving and investment ratio of a country will be uncorrelated only if the world rate of return is exogenous. That can only be supposed for small countries with small shares of the world capital market. So if a country has to be considered large, it will be able to influence the world rate of return which would lead to a correlation between saving and investment rates. In that case the correlation could not possibly be related to low capital mobility. FH had not found the country size to be of importance for the correlation coefficient. Furthermore, Frankel (1986) pointed out that in a cross section analysis the changes of the saving rate could not be attributed to influences of the world rate of return since all countries face the same rate.[6]

The only one who checked the endogeneity of the interest rate in a time series approach seems to be Frankel (1986). He reasons that with perfect capital mobility the changes in US savings should not affect US investment beyond its effect on the investment of the rest of the world. If so, deviations of the US saving ratio should not be correlated with deviations of the US investment ratio from the respective world ratio. But he found that they are. This was taken as

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[6] Failing to notice that, some authors did further investigate the issue, e.g. Murphy (1984) and Voss (1988).

evidence of the saving-investment correlation not to be attributable to a possible endogeneity of the rate of return.

Econometric criticism insufficient to shake results

The attempts to reject the FH results on grounds of econometric deficiencies can not be regarded successful. While a time series analysis indeed produced lower correlation coefficients, they still had to be considered incompatible with a high degree of international capital mobility. Also some finding hinted at a possible endogeneity of savings or of the world rate of return. But the estimated values of β never allowed to accept the hypothesis of zero (or low) correlation between saving rates and investment rates.

Does it matter which countries are included in the regression?

At first sight this question of sample sensitivity as to the countries included seems closely related to the issue of the possible endogeneity of the world rate of return. But while under the aspect of endogeneity the size of countries matters, here it is only of interest if any country can be included in the regression without substantially altering the basic findings.

The first approach to check for sample sensitivity was to alter the number of countries included in the sample. Where FH had based their regression on only 16 OECD-countries, the next study presented already comprised 87 countries.[7] Vos (1988) did the most extensive analysis, spanning 103 countries. The results proved to have a fairly low sample sensitivity.[8] The findings differed though for industrial and developing countries. Lower correlation coefficients for industrial countries would have been predicted according to the widespread opinion of their higher integrated financial markets. In fact, lower coefficients were obtained for the developing countries.[9] This startling fact could be convincingly explained by Frankel, Dooley and Mathiesen (1986) who divided developing countries into market borrowers and aid receivers. The regression coefficient of the market borrowers was not remarkably different from the one of the industrial countries. And the low correlation of savings and investment for countries depending primarily on official aid is not particularly surprising since foreign aid will not depend on the national saving rate of a developing country. So the original results could not be substantially altered by changing the country sample.

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[7] Fieleke (1982).

[8] Although some outliers (such as Luxembourg) did have some influence on the outcome.

[9] See, for example, Fieleke (1982) and Frankel, Dooley and Mathiesen (1986)

Are the results sensitive to the selected time period?

As to the time period, FH found the regression coefficient to be unaltered in the 1970s, indicating unaltered absence of capital mobility. As time went by, the time period under discussion was extended. While Murphy (1984) found the regression coefficient to be still unchanged from the original results[10], in the same year Caprio and Howard were the first ones to produce evidence of an increasing, albeit still low capital mobility. And in studies covering the majority of the 1980s, the estimated coefficient slowly decreased, but always remained significantly different from zero and always indicated surprisingly low capital mobility.[11]

Correlations between saving and investment rates robust empirical regularity

To sum up, the results of the original study have proven to be widely robust against changes in the applied econometric techniques and the sample of countries chosen. As to the time period, the picture emerged that while in the 1960s and 1970s the savings-investment correlation remained constantly high (not or hardly different from one), it decreased during the 1980s, but was still significantly different from zero (mostly above 0.5).

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[10] Remarkably, as late as 1990 studies were published hinting at a constantly low capital mobility. See Wong (1990).

[11] Sinn (1992), Montiel (1993), Argimón and Roldán (1994).

III.3. Benchmark Tests Enhance the Puzzle

Since the results obtained by FH were completely contrary to what had been deemed reality, some unknown factors were suspected to produce the observed, high correlations. To exclude this possibility, it was natural to compare the findings presented in the last subsection to those obtained for definitely highly integrated markets. As such national markets were regarded since capital can obviously flow freely between the regions of a country. No such things as capital controls or exchange rate risks can be detected. These tests estimating correlation coefficients for national markets became known as „benchmark tests".[12]

Based on data assembled by Roman (1965), Sinn (1992) regressed US federal state saving rates on federal state investment rates where state savings comprised private and public savings and investment was approximated by data for regional investment rates of eight industries. His results bore no evidence of a correlation between regional savings and investment rates. So according to this study, capital

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[12] The idea was developed by Murphy (1984). He computed the savings-investment correlations for the 143 largest U.S. industrial corporations. That seemed to be an appropriate benchmark because by nearly all standards the U.S. financial market is considered as highly integrated and the majority of the companies was at least graded AA, so the bonds they issued were supposed to be close substitutes. Surprisingly, he found a high and significant correlation of savings-investment correlations for these companies which seemed to hint towards undetected factors causing the parallel movements of the components. But then, considerable doubts were voiced whether bonds are really close substitutes. Companies can differ remarkably as to their solvency and their further development. So the approach was judged as poorly fitted for the intention of providing a benchmark.

mobility could indeed be regarded as perfect within the USA. Similar conclusions were reached by Bayoumi and Rose (1993) who tested the intra-regional capital mobility in the UK and also found savings and investment rates to be uncorrelated.

A completely different benchmark test was developed by Bayoumi (1990). He checked the impact of government policy on saving-investment correlations. Therefore he compared the correlation of the savings and investment rates of seven countries in the postwar period to those he estimated for the period of the gold standard (1880-1913) reasoning that these decades were characterized by hardly any capital controls or other forms of government interventions. So if the correlations were to be due to government interventions provoking low capital mobility, the correlation coefficients for the two periods should be similar. But he found the results to deviate considerably from those obtained for the decades 1960-1990. In fact the data did not provide evidence of a correlation between saving and investment in the gold standard period. It seemed justified to conclude that the observed high correlation was at least partly provoked by government actions.

All in all, these benchmark tests increased the puzzle. They showed low correlations between intra-regional savings and investment which was interpreted

as a proof of high capital mobility in (supposedly highly integrated) national financial markets. The high correlations found for international markets could thus not be attributed to some econometric misspecification (or a misguided intuition of the approach) that could otherwise have been suspected. An urgent need for explaining the phenomenon arose.

IV. Attempts to Resolve the Paradox

There is a wide range of possible explanations of the results generated by the FH approach. Two major approaches can be distinguished. One group of authors denies to accept the FH results as evidence of low capital mobility and constructed models producing correlations even under perfect capital mobility. The second group of authors tries to identify factors causing low capital mobility, thus generating the observed correlations.

IV.1. High Savings-Investment Correlations Despite Perfect Capital Mobility

The attempts to find explanations of the correlations in the presence of perfect capital mobility can be roughly subdivided into three groups: a) those who find the immobility of goods to be responsible, b) those identifying shocks as the

causal factors, and c) those who blame it to be a natural result of the intertemporal budget constraints of an economy.

Immobility of goods

First, the models featuring the immobility of goods as causal factors of high correlations between national savings and domestic investment will be described. It ought to be remembered that savings-investment correlations are a simultaneous measure of the degree of physical and financial capital mobility. Accordingly, these models are only sensible if they assume the immobility of a consumption good and not that of a capital good since that would already imply low (physical) capital mobility.

A model explicitly incorporating a non-traded consumption good was modeled by Engel and Kletzer (1987). In their infinite horizon, two-goods model, a non-traded consumption good and a traded composite good are produced. The argument is straightforward:

> „In the presence of non-traded goods, this independence of saving and investment breaks down. Production decisions obviously depend on consumption choices for the non-traded goods. As saving rises, suppose consumption of non-tradeables fall. However, the factor mix in the non-traded sector need not be the same as in the traded sector. As production in the home goods sector shrinks, factors of production must migrate to find employment. If the non-traded sector is relatively labor using, then marginal productivity of capital will rise in the economy when

> home goods production shrinks. This in turn implies the desired capital stock will rise, and there will be a positive relation between saving and investment."

This reasoning could provide an explanation for the observed correlation between saving and investment in an economy despite perfect capital mobility.

In a similar set-up, Wong (1990) rather concentrates on the wealth effect of increased savings. He argues that increases in savings raises the future wealth and therefore future consumption in an economy. The consumption of the non-traded good can only be extended if its production and accordingly investment in the non-traded good sector increases. Thus, a high positive correlation between savings and investment is provoked. In a model similar to that of Engel and Kletzer, Tesar (1993) specifies consumer preferences through the elasticity of substitution between traded and non-traded goods and the elasticity of intertemporal substitution. It can be shown that if consumers prefer national goods, that will also provoke a co-movement of national savings and domestic investment.

So the immobility of goods can generally provide an explanation of high savings-investment correlations in a country despite a high degree of international capital mobility. It can be intuitively grasped that this line of explanation might be of

considerable impact, since according to empirical studies the non-traded goods account for roughly 50 percent of the total economy.

Exogenous shocks

Models were developed where exogenous shocks serve to explain close co-movements of national savings and domestic investment. The models were generated in two basic forms of macroeconomic models, the infinite-horizon model and the overlapping-generation model. The shocks prevailing in the models are either shocks on the terms of trade or productivity shocks.

Persson and Svensson (1985) derive the responses of savings and investment to a terms-of-trade shock in a small open economy, overlapping generations model with complete specialization in production with two goods. The shock hitting the terms of trade alters the real rate of return to domestic capital (while by assumption the world interest rate remains unchanged). That induces a change in the investment rate. The savings rate responds to the change in the capital stock. The magnitude of the correlation depends critically on the degree to which the shock is anticipated and to the assumed time lag of capital stock adjustment.

Obstfeld (1986) was the first to construct a model incorporating a productivity shock in an infinite horizon, two country set up. Due to adjustment lags in

investment, the rate of return will temporarily rise above its equilibrium level. Accordingly, until the capital stock is adjusted, wages will rise above the new equilibrium level. so if the shock is sufficiently transitory, i.e. if future disinvestment and therefore reduced wages are expected, savings are induced in order to smooth future consumption. It should be noted to be transitory is critically in order to generate the desired correlation between savings and investment.

Obstfeld presents in the same paper an overlapping-generations model where the population growth induces co-movements of savings and investment rates. Tesar (1988) combines this idea and the one of Persson and Svensson and incorporates technology shocks into an overlapping-generation model. If the shock, either permanent or transitory, is unanticipated, the economic agents will increase saving and investment.[13] This effect is not observed if the shock is anticipated, because investment will always be kept at its optimal level avoiding windfall gains. Also based on the model by Obstfeld, in a two country setting Backus, Kehoe and Kydland (1989) allow workers to trade contingent bonds on their labor income. As a result, the link between wages and savings is broken and the

[13] The rationale is congruent with the one in the Obstfeld model: Saving rates are raised in order to smooth consumption and investment rates because the domestic interest rate temporarily exceeds the world interest rate.

correlations between savings and investment are quite low. Refining the model, Baxter and Crucini (1989) introduce adjustment costs of the capital stock. Thus, capital flows are reduced and correlations raised again (as compared to the model by Backus, Kehoe and Kydland).

Finn (1993) constructs a rather complex stochastic overlapping-generations, two-country model of savings and investment under conditions of perfect international capital mobility. She is able to show that under uncertainty positively technology shocks which are both autocorrelated and correlated across countries can produce positive correlations of saving and investment[14]

All in all, permanent shocks can serve to explain long-run co-movements between savings and investment, but they are unable to explain the observable short-run correlations between the two components. On the other hand, models incorporating temporary shocks can produce short-run co-movements but fail to generate long run co-movements. So if the empirical regularity of high savings and investment correlations were to be explained by exogenous shocks exclusively, either constantly permanent and transitory shocks would have to

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[14] She finds fiscal and monetary shocks to be of minor importance.

occur simultaneously or temporary shocks would have to happen frequently enough.

Intertemporal budget constraints

A third argument trying to explain the FH results even under perfect capital mobility has been developed recently by Coakley, Kulasi, Smith (1996). They argue that the current account should be a stationary process[15] since the solvency constraint of an economy requires debt not to explode. A model is developed where this solvency constraint is operationalized by adding an error-correction term to the investment equation. Economically the error-correction term can be interpreted as a market risk premium. They find the model to be consistent with the data and conclude that the solvency condition of an economy entails the observed correlations of saving and investment.

[15] They concede that the issue if the current account is stationary has not really been settled. Gundlach and Sinn (1992) obtained results showing the current account being integrated of order one in the USA, in Germany and in Japan. Recently though there seems to be a consensus emerging as to the stationarity.

Models can theoretically explain high correlations between savings and investment despite high degree of capital mobility

To sum up, it can be said that the models can explain the observed correlations between savings and investment despite perfect capital mobility. On these grounds, the FH approach can – a priori – no longer be regarded as a measure of capital mobility. Up to today though, the empirical relevance of these models is not quantified, it is unknown if and to what extent they serve to explain the empirical regularity of close co-movements between savings and investment.

IV.2. Conceivable Reasons of Low Capital Mobility

Besides the possibility of high correlations despite perfect capital mobility pointed out above, a second possibility exists, the possibility of market imperfections leading to the parallel movement of savings and investment. Less than perfect capital mobility could be due to two reasons: a) individuals are prohibited (or restrained) in moving the capital, b) individuals reject moving capital. If a) were to be decisive, low capital mobility ought to be due to government policy.

Government intervention

There is a variety of ways in which governments can restrict the mobility of physical or financial capital. As to diminishing the mobility of physical capital, tariffs can be levied, quotas imposed or even an import or export stop can be proclaimed. The free flow of financial capital will be hindered by capital controls. But also measures to promote capital inflows can be imagined such as tax breaks on foreign investment.

The first to ascribe the high correlations between savings and investment to government interventions was Fieleke (1982). Bayoumi (1990) was the first to test the hypothesis of government actions hindering capital flows. He computed correlation coefficients for 10 industrial countries covering the time period 1960 to 1986, regressing the total amount of savings on investment as well as regressing only the private savings on private investment. If low capital mobility was to be due mainly to the behavior of the private sector, the results obtained for that sector should be higher or at least as high as those obtained for the complete economy. This was not the case, indeed the correlations for the private sector were far lower than for the economy as a whole. These results were interpreted as evidence of governments aiming at balancing the current account. The question by which means governments target the current account was further investigated

in a paper by him and Artis (1991). They concentrated on the effects of monetary policy on the current account by estimating a reaction function of the form

$$\text{(IV.1)} \qquad \Delta r = \alpha + \beta y + \gamma \Delta p + \delta \frac{CA}{y} + \mu$$

with r as the discount rate, p presents the price level, y is the GDP (or GNP) and CA/y the ratio of the current account to GDP. μ is a random error term. If monetary policy was to be used by governments to target the current account, δ ought to be negative. This notion was confirmed by their results. Accordingly, they deemed monetary policy to be an important tool of governments in manipulating the current account balance. This result was confirmed by Argimón and Roldán (1994) who investigated the possible effects of fiscal policy on the current account balance.[16] From an econometric point of view, if the intertemporal budget constraint of a country is to hold, it requires a long-run relationship between savings and investment, i.e. cointegration and the current account would have to be a stationary series. On the grounds that

$$\text{(IV.2)} \qquad (S_P - I_P) + (S_G - I_G) = CA$$

where the suffix P denotes the private sector and the suffix G the public sector, a cointegration between the public gap and the private gap (in the sense of the

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[16] A study similar to the one under discussion was conducted by Ballabriga, Dolado and Vinals (1991) who arrive at comparable conclusions.

public sector reacting to the private sector) should exist. The authors find that national savings and investment are cointegrated with savings acting as the restraint for investment. But a cointegration relationship could neither be detected for the private nor for the public sector. Furthermore, the public gap reacts to the private gap only in those countries which were late in abolishing capital controls (e.g. Spain). The results imply that budgetary policy was not widely used to target the current account balance.

Market imperfections

It cannot be ruled out that the observed correlations of savings and investment are produced by other market imperfections such as the heterogeneity of goods and/or incomplete information.

It has been shown that the FH approach is a simultaneous measure of physical and financial capital mobility. Especially physical capital has to be regarded as highly heterogeneous. Accordingly, imperfections in the markets for capital goods have to be suspected impeding the free flow of physical capital to its place of best use, i.e. highest rate of return. The point of view, tracing the high correlations of saving and investment to imperfections in the goods markets, is advocated by Frankel (1986). The influence of imperfect information on the behavior of savings

and investment is investigated by Stefani (1994).[17] Her basic idea is that asymmetric information will leave individuals at odds as to the realistic rate-of-return and the risk of investments abroad. To be on the safe side, they will thus tend to invest at home inducing co-movements of savings and investment.

These ideas might obviously also be of relevance in explaining the high saving-investment correlations. Evaluating the two lines of research is left to further studies. Furthermore, it is striking to compare the meager amount of studies available on the possible impact of market imperfections to the extensive body of research trying to explain high savings-investment correlations despite perfect capital mobility.

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[17] She also constructs a model intended to show the influence of asymetric information. Unfortunately, she incoporates an immobile capital good into the model. Since the FH approach measures the mobility of physical and financial capital, it cannot be ruled out that the immobility of the capital good causes the observed correlation rather than the asymmetric information of the residents.

V. Quintessence

The high correlations between savings and investment turned out to be a surprisingly robust empirical regularity. Neither alterations in the econometric approach nor in the number of countries nor in the time period could influence the results substantially.

Disappointingly though, we still do not know if a paradox exists or not. Models have been developed producing even under perfect capital mobility correlations similarly to those observed. At the same time plausible arguments exist holding imperfect (good or financial) markets responsible of the co-movement of savings and investment. The empirical relevance of the competing explanations has not been determined so far. Accordingly, it cannot be decided if the observed empirical regularity serves as a measure of the degree of international capital mobility or not. If the models generating these correlations under high capital mobility should bear the greatest explanatory power, obviously the FH approach would not be a valid measure of international capital mobility. On the other hand, if the models would prove to be of only minor importance empirically, the approach could well serve as a straightforward measure of international capital mobility with high correlations reflecting high degrees of market imperfections.

As a first hint to quantifying the relevance of the models assuming perfect capital mobility, it should be noted that these models completely oppose the benchmark tests that provide evidence of an extremely low intra-national correlation between savings and investment. If non-traded goods, shocks or intertemporal budget constraints were decisive in explaining the FH results, saving-investment correlations should also be observed if estimated for different regions within a country, since the existence of regional non-traded goods, regional shocks and even regional budget constraints appears to be highly probable.

This contradiction can either be due to the empirical irrelevance of the models or by assuming misspecifications in the benchmark tests. In order to settle the issue, further studies are needed. Also the evidence on possible imperfections of financial markets, i.e. asymmetric information and the influence of institutions such as national laws, is restricted. So future research should aim at sharpening the understanding of the empirical regularity by proceeding along two major lines: First, evaluate the empirical relevance of the models and second, provide evidence of perceived imperfections of capital markets. Investigating different subsections of capital, such as bonds, equities etc. will presumably yield better insights than trying to approach capital mobility as a whole as done by FH.

VI. Appendix

Appendix D: Survey on Studies Estimating Savings-Investment Correlations in Chronological Order

Year	Author/s	Econometric approach	Sample and time period	Values of β	Special features
1980	Feldstein Horioka	Cross section	16 OECD countries 1960-1974	β not significantly different from one, but from zero	– First ones to compute savings-investment correlations
1982	Fieleke	Cross section	87 countries 1968-1977	β obtained for developing countries higher than for industrial countries	– Way of addressing country size – Including LCD's – Government interventions as explanation
1984	Murphy	Cross section	OECD countries 1960-1980	β not significantly different from one, but significantly different from zero	– Assessment of the role of country size – Benchmark test
1984	Caprio, Howard	Cross section	23 OECD countries 1963-1981	β different from unity and from zero	– Considering the possible influence of business cycles
1984	Penati, Dooley	Cross section Time series	19 ICs 1960-1980	β not significantly different from one, but from zero	– First ones to apply time series analysis
1986	Frankel, Dooley Mathiesen	Cross section	14 ICs 50 LCD's 1960-1984	β higher for industrial countries than for developing countries	– Dividing LCD's in market borrowers and aid receivers – Different way of correcting for the country size

Table D) continued

Year	Author/s	Econometric approach	Sample and time period	Results	Special features
1986	Obstfeld	Time series	7 OECD countries 1959-1984	β significantly different from one and zero; lower in the eighties than in former decades	– Theoretical model to support time series approach – Closer look at NIA data – Quarterly Data
1986	Obstfeld	Time series	OECD countries 1950-1984	β not significantly different from one, but from zero	– Time series on basis of annual data
1986	Frankel	Time series	USA 1870-1984	β not significantly different from one, but from zero	– Conclusion that observation is due to imperfect good markets rather than financial markets
1988	Vos	Cross section	18 ICs 87 LCD's	β lower in the eighties than in former decades	– Data source and computation
1988	Summers	Cross section	23 OECD countries 1960-1983	β not significantly different from one, but from zero	
1989	Feldstein, Bacchetta	Cross section	23 OECD countries 1961-1986	β lower in the eighties than in former decades	– Division into EC and Non-EEC countries
1990	Wong	Cross section	45 countries 1975-1981	β not significantly different from one, but from zero	– Theory and test of the influence of the non-traded sector

Table D) continued

Year	Author/s	Econometric approach	Sample and time period	Results	Special features
1990	Bayoumi	Cross section Time series	10 Industrial countries 1960-1986	β lower in the eighties than in former decades	– Splitting investment into fixed and inventories – Comparison with gold standard period – Considering Ricardian equivalence
1992	Sinn	Time series.	23 OECD countries 1960-1988	β significantly different from unity and from zero	– That form of time series – Benchmark test for the USA
1993	Bayoumi, Rose	Time series	UK 1971-1985	β not significantly different from zero	– Benchmark test for the UK
1993	Montiel	Cross section	62 developing countries 1970-1990	β significantly different from unity and from zero	
1994	Argimón Roldán	Cross section	Countries of the European Community	β values differ substantially between countries	– Test for cointegration

Appendix B: Model Incorporating an Exogenous Shock to Produce Saving-Investment Correlations Despite Perfect Capital Mobility

Obstfeld assumes for the model an infinite time horizon in a non-stochastic environment is assumed. The world interest rate is supposed to equal the domestic interest rate ρ and capital markets are perfect. Demand of labor equals supply of labor and is fixed (N=1). Accordingly, labor is immobile and paid wages (w).

The representative consumer

The representative immortal consumer holds his or her non-human wealth at time t either in foreign bonds (b_t) or in shares of the single domestic firm (h_t)($0 \leq h_t < 1$). Shares pay dividends (d_t); q_t denotes the firm's ex-dividend market value and v_t the discounted value of dividend payments. It is assumed that the individual prefers a perfectly flat consumption path implying the discount factor (β) to equal $\frac{1}{1+\rho}$ and aims at maximizing his or her utility derived from consumption

$$\text{(A.1)} \qquad \text{Max} \sum_{t=1}^{\infty} \beta^{t-1} u(c_t)$$

Consumption is restricted by the sum of factor payments and the change in non-human wealth

(A.2) $$c_t = \underbrace{w_t + d_t h_{t-1} + \rho b_{t-1}}_{\text{factor-payments}} + \underbrace{q_t(h_{t-1} - h_t) + (b_{t-1} - b_t)}_{\text{change in non-human wealth}}$$

The lifetime budget constraint combined with the objective to realize the highest consumption level possible implies that discounted consumption must equal the discounted sum of factor payments plus the original non-human wealth.

(A.3) $$\sum_{t=1}^{\infty}(1+\rho)^{-(t-1)} c_t = \sum_{t=1}^{\infty}(1+\rho)^{-(t-1)} w_t + (q_1 + d_1)h_0 + (1+\rho)b_0$$

which yields

(A.3a) $$c_t = \left(\frac{\rho}{1+\rho}\right)\left[(q_t + d_t)h_{t-1} + (1+\rho)b_{t-1} + \sum_{j=0}^{\infty}(1+\rho)^{-j} w_{t+j}\right]$$

The amount of saving at time t is accordingly given by

(A.4) $$S_t = w_t - \rho\sum_{j=0}^{\infty}(1+\rho)^{-(j+1)} w_{t+j} \quad \text{which equals}$$

(A.4a) $$= (1-\alpha)\left(\frac{\alpha}{\rho+\delta}\right)^{\frac{\alpha}{1-\alpha}}\left(v_t - \rho\sum_{j=0}^{\infty}(1+\rho)^{-(j+1)} v_{t+j}\right)$$

The domestic firm

Let us consider now the behavior of the domestic firm. The input factors of the firm are labor (n) which is paid wages (w_t) and domestic capital (k_t) which

depreciates at rate δ. Installation of capital is costless and takes one period, but may not be removed from production until the following period (i.e. the stock of capital is predetermined). Output at time t is a constant return function $\theta_t f(k_t,n_t)$ where θ_t denotes a factor-productivity disturbance. Perfect capital mobility in a small open economy implies that capital invested in the domestic firm has to yield the same rate of return as it is paid worldwide.

$$\text{(A.5)} \qquad \rho = \left(\underbrace{(q_{t+1} - q_t)}_{\text{Retained earnings}} + \underbrace{d_{t+1}}_{\text{dividends}} \right) / q_t$$

The firm will maximize the value of the discounted dividends which equals the amount of discounted output minus discounted wage payments minus retained earnings (which by definition equals investment)

$$\text{(A.6)} \qquad v_t = \sum_{j=0}^{\infty} (1+\rho)^{-j} d_{t+j} \quad \text{which yields}$$

$$\text{(A.6a)} \qquad = \sum_{j=0}^{\infty} (1+\rho)^{-j} \left[\theta_{t+j} f\left(k_{t+j}, n_{t+j}\right) - w_{t+j} - k_{t+j+1} + (1-\delta) k_{t+j} \right]$$

In order to maximize the firm's value, an optimal capital stock and wage level have to be chosen. The capital stock is optimal if its marginal productivity equals the world interest rate plus the depreciation rate.

$$\text{(A.7)} \qquad f'(k_t) = \theta_t \alpha k_t^{\alpha-1} n^{1-\alpha} = \rho + \delta$$

Accordingly , the capital stock is given by

(A.8) $$k_t = \left(\frac{\alpha \theta_t}{\rho + \delta}\right)^{\frac{1}{1-\alpha}}$$

The wage rate will be optimal if it equals marginal productivity of labor.

(A.9) $f'(n) = \theta_t (1-\alpha) k^{\alpha}$

(A.9a) $$w_t = (1-\alpha)\left[\frac{\alpha}{\rho + \delta}\right]\theta_t^{\frac{1}{1-\alpha}}$$

If the above applies, the value of the firm at the end of one period has to equal its capital stock at the beginning of the following period.

(A.10) $q_t = k_{t+1}$

When the productivity parameter (υ) is given by $\theta^{\frac{1}{1-\alpha}}$, investment is just the difference between the capital stock in period t+1 and the one in period t

(A.11) $I = k_{t+1} - k_t$ which is equivalent to

(A.11a) $$= \left(\frac{\alpha}{\rho + \delta}\right)^{\frac{1}{1-\alpha}} (\upsilon_{t+1} - \upsilon_t)$$

The shock and its consequences

Now let us suppose the shock occurs in period 1 raising productivity unexpectedly and let us see how saving and investment will react. It is assumed that from period 1 onward the productivity parameter follows the path

(A.12) $$\upsilon_t = \upsilon + \lambda^{t-1}(\upsilon' - \upsilon) \qquad 0 < \lambda \leq 1$$

If the persistence parameter λ is smaller than 1, the productivity increases only temporarily and decays at rate λ. For if λ equals 1, the increase is permanent. By assumption decisions on the „optimal" capital stock for this period were already met in the foregoing period. The capital stock cannot be adjusted immediately. Therefore, the desired (equilibrium) capital stock will exceed the actual stock. Subsequently, investment will rise in period 1 in order to adjust the capital stock to its new marginal product.

(A.13) $$I_1 = \left(\frac{\alpha}{\rho + \beta}\right)^{\frac{1}{1-\alpha}} \lambda(\upsilon' - \upsilon) > 0$$

If no further shocks occur, investment will be zero from now on, if the shock is permanent; it will be negative if the shock is transitory. That yields

(A.14) $$I_t = \left(\frac{\alpha}{\rho + \beta}\right)^{\frac{1}{1-\alpha}} \left[(\lambda - 1)\lambda^{t-1}(\upsilon' - \upsilon)\right] \leq 0$$

Now consider the behavior of national saving. In the first period, consumption will rise to the highest level deemed to be constantly obtainable taking into account the increase in productivity. Saving will therefore equal

(A.15) $$S_1 = \left(\frac{1}{1+\rho}\right)\text{the} \quad \underbrace{\left[w_1 - \rho\sum_{j=1}^{\infty}(1+\rho)^{-j}w_{j+1}\right]}_{\text{Difference between current wage and discounte rate weighted future wages; the term is positive if shock is transitory}} + \underbrace{\left[q_1 + d_1 - (1+\rho)q_0\right]h_0}_{\text{Windfall gains}}$$

The above can be rewritten as

(A.15a) $$S_1 = \left(\frac{1}{1+\rho}\right)\left[w_1 - \rho\sum_{j=1}^{\infty}(1+\rho)^{-j}w_{j+1}\right] + (\rho+\delta)\left[\left(\frac{\upsilon'}{\upsilon}\right)^{1-\alpha} - 1\right]k_1h_0$$

Here the windfall gains are expressed as the difference between the new marginal productivity of the capital stock and its old marginal productivity. The abnormal profits are expected to disappear in the next period, so that only the fraction $\frac{\rho}{1+\rho}$ is consumed in period 1. Now, in order to determine if the savings will move in the same direction as investment, it has to be quantified. It is obvious that the persistence parameter has no influence on the amount of the windfall gains which are always positive. However, the persistence parameter influences decisively the influence of wages on savings. If the productivity shock is permanent, the wage in period 1 rises to the level

(A.16) $$w_1 = (1-\alpha)(\upsilon')^{1-\alpha}k_1^{\alpha} \text{ which equals}$$

(A.16a) $$= (1-\alpha)\left[\frac{\alpha}{\rho+\delta}\right]^{\frac{\alpha}{1-\alpha}}(\upsilon')^{1-\alpha}\upsilon^{\alpha}$$

which is the marginal productivity reached with the new productivity and the unadjusted capital stock. It lies between the pre-shock wage and the permanent wage expected to prevail from period 2 onward

$$(A.17) \qquad w_2 = (1-\alpha)\left[\frac{\alpha}{\rho+\delta}\right]^{\frac{\alpha}{1-\alpha}} \upsilon' \text{ (see equation A.9a)}$$

So the wage in period 1 is below its permanent level, and the first term in A.15 will therefore be negative and equal to

$$(A.18) \qquad \left[w_1 - \rho\sum_{j=1}^{\infty}(1+\rho)^{-j}w_{j+1}\right] = \left(\frac{1}{1+\rho}\right)(1-\alpha)\left[\frac{\alpha}{\rho+\delta}\right]^{\frac{\alpha}{1-\alpha}}\left[(\upsilon')^{1-\alpha}\upsilon^{\alpha} - \upsilon'\right]$$

If all shares in period 0 are domestically owned (h_0 equals 1), first period saving will accordingly equal (equation A.16 plus equation A.18)

$$(A.19) \qquad S_1 = \left(\frac{1}{1+\rho}\right)\left[\frac{\alpha}{\rho+\delta}\right]^{\frac{\alpha}{1-\alpha}}\left[(\upsilon')^{1-\alpha}\upsilon^{\alpha} - (1-\alpha)\upsilon' - \alpha\upsilon\right]$$

which is unambiguously negative since the second term in braces is only an enlargement of the second term in braces in A.18, which is already negative. It can be concluded that the negative impact of the wage differentials on savings will prevail over the positive impacts of the windfall gains. Period 1 saving is even smaller if not all shares are domestically owned, since a part of the windfall gains will then accrue to foreigners. That means that if the productivity shock

hitting the economy is perceived as permanent, there will be hardly any time-series correlation between savings and investment.

What will happen in the case the shock is perceived as temporary? The saving in period 1 will then be given by

(A.20)

$$S_t = \left(\frac{1}{1+\rho}\right)\underbrace{\left[(1-\alpha)\left(\frac{\alpha}{\rho+\delta}\right)^{\frac{\alpha}{1-\alpha}}(\upsilon')^{1-\alpha}\upsilon^{\alpha}\right] - \left[\rho\sum_{j=1}^{\infty}(1+\rho)^{-j}(1-\alpha)\left(\frac{\alpha}{\rho+\delta}\right)^{\frac{\alpha}{1-\alpha}} - \left(\upsilon+\lambda^{t-1}(\upsilon'-\upsilon)\right)\right]}_{\text{difference between actual wage level and future discount rate weighted level}}$$

$$\underbrace{+\alpha\left(\frac{\alpha}{\rho+\delta}\right)^{\frac{\alpha}{1-\alpha}}\left[(\upsilon')^{1-\alpha}\upsilon^{\alpha}-\upsilon\right]h_0}_{\text{windfall gains}}$$

which equals

$$20.a\quad S_t = \left(\frac{1}{1+\rho}\right)\left[\frac{\alpha}{\rho+\delta}\right]^{\frac{\alpha}{1-\alpha}}\left\{\left[1-(1-h_0)\alpha\right]\left[(\upsilon')^{1-\alpha}\upsilon^{\alpha}-\upsilon\right]-(1-\alpha)\left[\frac{\rho\lambda}{1+\rho-\lambda}\right](\upsilon'-\upsilon)\right\}$$

Omitting the windfall gains, which are always positive, saving can be rewritten as (using equation A.4)

$$21.\ S_t = \left(\frac{1}{1+\rho}\right)\left(\frac{\alpha}{\rho+\delta}\right)^{\frac{\alpha}{1-\alpha}}(\upsilon'-\upsilon)\left[\frac{(1-\lambda)\lambda^{t-1}}{(1+\rho-\lambda)}\right] \qquad t\geq 2$$

The right-hand term will be positive if λ is sufficiently small which is equivalent to the shock being sufficiently transitory. Now it is clear that saving and

investment will be positively correlated if a shock hits the economy which is perceived as rather temporary. That implies that a positive correlation between saving and investment need not have anything to do with less than perfect capital mobility.

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